

Technology and teaching in engineering education: A blended course for faculty

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ABSTRACT

This paper provides a case study description of a teaching development course for engineering faculty. Findings indicate that faculty engaging in a blended course about online and blended learning perceive significant benefits to the learning design. Perceived benefits far outweighed concerns about this alternative to classroom teaching alone.

KEYWORDS

Engineering education, higher education, teaching, learning, faculty roles, Standards: 8, 9, 10, 12

INTRODUCTION

During the last decades, an explosion of digital tools to support daily life have been introduced. Online and blended learning is one such tool; it offers the opportunity to support higher education through web-based content delivery and interaction. But the success of online and blended learning delivery is dependent on the knowledge and expertise held by faculty about this new way of teaching and learning.

This paper reports results from an exploratory case study of a teaching development course at KTH Royal Institute of Technology in Stockholm, Sweden. This research method was chosen to “allow the research community to be able to better address questions around key engineering education challenges ...” (Case & Light, 2011, p. 186.). The challenge addressed through this research refers to the larger education reform movement in higher education.

Findings indicate a notable range of responses from faculty to the design and use of blended learning but a definite interest in the use of technology for learning. This paper includes 1) a description of the context in which the course is offered to faculty, 2) information about how this blended course about blended teaching and learning was created, and 3) conceptual themes that emerged from analysis of discussion forum posts about the use of blended communities’ of inquiry for engineering education.

BACKGROUND INFORMATION

In the transition from traditional, lecture-based, classroom teaching is a silent conundrum; teachers using this ‘tell them and test them’ method of teaching require little or no expertise in instructional design, learning theory, teaching strategies beyond the lecture, or learning assessment. Using online and blended learning in teaching includes “the development of teaching materials, the instructional design and the pedagogy of the delivery including assessment strategy.” (Lucke et al., 2016, p. 3). More than just a move to using the technology, online and blended learning requires new ways of designing courses and teaching. While there are great advantages to doing this, the required time and expertise

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make it more difficult for faculty to be exemplars in both teaching and research (Fairweather, 2002). Support, and training, is one way to address this difficulty.

As an opportunity for faculty at KTH Royal Institute of Technology to develop skill and expertise in online and blended teaching, we created a course titled *Teaching Strategies and Design for Online and Blended Learning*. The course is equivalent to two weeks of full-time study. KTH, and other higher education institutions in Sweden, require at least ten weeks of full-time study in the field of teaching and learning in order to be tenured. For a copy of the course syllabus in English, see <https://www.kth.se/student/kurser/kurs/LH218V?l=en>.

KTH was founded in 1827 as the premier technological school in Sweden, offering subjects in science with a practical, professional focus. KTH is Sweden's oldest and largest technical university. Approximately one-third of Sweden's technical research and engineering education capacity at university level is provided by KTH. Currently, 13,400 first and second level students and 1,900 doctoral students study at KTH.

KTH has remained a leading-edge institution since its inception. Recently, KTH created a Vision 2027 strategy: "Information technology as an integral part of everyday life will have altered conditions for university studies fundamentally by 2027. Competition is becoming global when courses, to an ever larger extent, are offered via cloud computing networks and when teaching materials are becoming omnipresent. E-education is a self-evident part of competitive bids for university studies. There is a special challenge in acquiring and maintaining a leading position in both ICT research and e-education."

The teaching development initiative reported here responds to the above vision and to two calls for change in higher education. The first is the need to improve expertise on teaching and learning among faculty in higher education (Rienties, Brouwer, & Lygo-Baker, 2013). The second, as indicated in KTH's vision, is to create expertise among faculty regarding e-education, and the use of ICTs for teaching and learning.

LITERATURE REVIEW

Engineering education exists within the higher education enterprise, where demands for change impact all disciplines, fields of study, and programs. This literature review begins with a review of the need for change specifically in teaching and learning in higher education. Training in online and blended learning represents a significant form of faculty development for teaching and learning. This is also outlined below. Review of specific research in online engineering education completes this segment of this paper.

Over the last two decades, "... classroom teaching and course materials (have become) more sophisticated and complex in ways that translate into new forms of faculty work...such new forms are not replacing old ones, but instead are layered on top of them, making for more work" (Rhoades. 2000, p. 38). This layering rests on the top of a spotty foundation of teaching and learning expertise on the part of faculty. Making changes in one's practice is difficult at any time but is a greater challenge when there is little foundation on which to assimilate new ways of doing things. By the time a faculty appointment is offered, most academics have a promising record of expertise in research. And while some new faculty will have teaching experience in the lecture hall, too many will enter the academy without the fundamental pedagogical knowledge required for good teaching, The general assumption is

that good teaching 'comes naturally' (Beckerman, 2010). Recognizing that teaching does not always come naturally for many faculty, institutions of higher education now offer courses to improve teaching quality by increasing pedagogical expertise. This paper reports the faculty experience in such a course.

This course served as an education experience for KTH faculty who are interested in online and blended learning design. It was created with reference to multiple learning theories and delivery opportunities. First, the textbook and the orientation to design and delivery in this course are based on the online Community of Inquiry model (Garrison, Anderson & Archer, 2000; Vaughan, Cleveland-Innes, & Garrison, 2013). The model rests on Dewey's (1910) views on experiential learning and is constructivist in nature. The roles of instructor and student are transformed by three overlapping presences: cognitive, social, and teaching presence. Social presence emerges through the ability of participants to connect with the others in the community, the opportunity, through facilitation, to communicate purposefully in a trusting environment, and to develop relationships by projecting their individual personalities and acknowledging others who are doing the same. Cognitive presence describes the degree to which learners are able to construct and confirm meaning through sustained reflection and discourse. The third and central organizing element is teaching presence. Teaching presence is available to the instructor and the students. It is created through the design, facilitation, and direction of cognitive and social processes such that personally meaningful and educationally worthwhile learning outcomes can be realized.

A blended Community of Inquiry is a method of course delivery guided by the "thoughtful integration of classroom face-to-face learning experiences with online learning experiences" (Garrison & Kanuka, 2004, p. 96). As such, blended learning can be integrated into all parts of the CDIO syllabus (CDIO Syllabus 2.0, n.d). Guided by the Community of Inquiry model, the disciplinary knowledge and reasoning as well as personal and professional skills and attributes are manifested by the individual's practical inquiry that is structured as cognitive presence. Interpersonal skills: teamwork and communication is embedded in the collaborative and constructivist approach to learning that is manifested in the Community of Inquiry and can particularly be visualized by the open communication, and group cohesion of social presence. The processes of conceiving, designing, implementing and operating systems in an educational context can be of the design and organization of teaching presence. Here, it is important to note that the element of teaching presence is the responsibility of the instructor(s) but can be displayed by any participant as they understand, monitor, and regulate their own or peer-students learning. Collaboration is most important.

Although time consuming, collaborative instruction is central to the benefits of online teaching and learning. The individualization of communications, and the role of instructor as a facilitator of student participation and learning, add to the instructor workload when teaching online (Davidson-Shivers, 2009). In balance, a central teaching advantage of online delivery is the opportunity to better engage learners in more active and collaborative educational experiences. Tomei (2004) proposes that online student expectations for on-demand, continuous feedback necessitates smaller class sizes relative to those in traditional classroom instruction. Reducing class size is one option available to compensate for the imposition of time online teaching will impose; a value added in any delivery method. For Tomei then, the 40-40-20 formula for allocating faculty time (40 percent teaching, 40 percent research, and 20 percent service) suggested by the American Association of University Professors (AAUP) must be reshaped for faculty teaching in an online environment. Given

this, it is unrealistic to assume that emerging Internet technologies will transform teaching practices in higher education without changing how faculty work. (Yick, Patrick, & Costin, 2005).

METHODS

Case study research is an emerging methodology in engineering education (Case & Light, 2011). It is an acceptable method, particularly in education research, where the research purpose is to explore, describe, or explain findings emerging in a bounded but complex environment. This exploratory study is a test of the theoretical premise that experience in an online course will provide faculty the opportunity to evaluate the value of such. In this case, faculty experience an online and blended learning environment to learn about teaching in such an environment.

This experience was offered to teachers at KTH through the course *Teaching Strategies and Design for Online and Blended Learning*. The theoretical part of the course is from the extensively researched theory of an online Community of Inquiry (Vaughan, Cleveland-Innes, & Garrison, 2013). This theoretical framework represents a process of creating a deep and meaningful (collaborative-constructivist) learning experience through the development of three interdependent elements - social, cognitive and teaching presence. In agreement with Lucke, Brodie, L., Brodie, I., & Rouvrais (2016) and Norrman, Bienkowska, Moberg, & Frankelius (2014), well-designed online and blended learning can support CDIO-based engineering education.

Design opportunities were offered in the application part of the course where participants designed a module of online and blended learning. The expectation, beyond the course requirements themselves, is that the module will be implemented in a course of the participants' field. In addition to experiencing online and blended learning, application practice allowed participants to test and evaluate tools and techniques often used in online and blended education. The tools are chosen among those which are supported at KTH.

Participants in this study hold positions related to instruction at KTH. Participation is voluntary. Credits received for taking the course satisfy pedagogical training requirements; in order to be appointed as associate or full professor at KTH, faculty must have 10 weeks of courses in teaching and learning in higher education. The course ran once per year in each year 2013, 2014, and 2015.

For this study, data were drawn from discussion posts in Week 2 of the course that focused on the conceptual framework of the Community of Inquiry model for online and blended learning in engineering education. Participants were asked to read *Teaching In Blended Learning Environments* by Vaughan, Cleveland-Innes & Garrison (2013) and answered questions on 1) their perceptions of the model, 2) which activities work best for teaching face-to-face versus online, and 3) how they could use each aspect of teaching presence in support of teaching principles.

As the data review was based on concepts outlined in the Community of Inquiry theoretical framework, a deductive method of data coding was employed. Two coders identified key concepts they believe would be valuable when analyzing the data. A final structure was then negotiated based on the two lists. Coding proceeded separately by each coder and an inter-rater reliability score will be assessed and reported. For dialogue that did not fit within the

final coding structure, we instead used inductive coding. For this section of the data, a process of open or free coding followed by axial or verification coding, and finally confirmatory coding was employed (Neuman, 2011).

A total of 52 university employees took this course over three years. The distribution of respondents according to schools is outlined in Table 1. below. Table 2. outlines distribution across academic rank.

Table 1. Number of participants by school

KTH School	2013	2014	2015	Grand Total
Architecture and the Built Environment	2	2	5	9
Biotechnology		1	1	2
Chemical Science and Engineering	3	2	2	7
Computer Science and Communication		1	1	2
Education and Communication in Engineering	3	1	2	6
Electrical Engineering		1		1
Industrial Engineering and Management		2	1	3
Information and Communication Technology	1	1	1	3
Engineering Sciences	2	4		6
Technology and Health	1	3	4	8
External		3	2	5
Grand Total	12	21	19	52

Table 2. Participants by rank

Title	Total
Assistant Professor	9
Associate Professor	8
Lecturer	12
Other	7
Ph.D. student	1
Postdoc	1
Researcher	14
Grand Total	52

FINDINGS

Four themes emerged and were verified through sequential coding processes. Over three course offerings a total of 18,243 words made up the forum discussions about blended and online learning (Week 2). Any text from facilitators, or about general course logistics, was removed.

The message was the unit of analysis. Word counts are used as a baseline and a way to view amounts for comparison. For this discussion, 9% of words in the total word count of all three semesters focused on the topic of challenges perceived or resistance to the use of online and blended learning. The remainder were divided into 15% for general learning design, 48% for perceived benefits of blended and online learning, and 28% for ideas for making changes in current teaching methods and/or learning design through online and blended learning. Below is a description of each theme with examples of coded messages for each. Figure 1. graphically presents the relative amounts of different themes.

Challenges/Resistance (9%) refers to messages about reasons to not consider or adopt blended or online learning in engineering education. Messages referred to issues such as technology access, student readiness, and time constraints. Examples are:

- "...from the perspective of student learning, a lot of one-to-one instruction is the best."
- "If you just open a discussion forum ... the students are most probably not going to use it for internal discussions."

General learning design (15%) is a theme which captures more general statements about learning design in any delivery mode. Discussing opportunities in online and blended learning provides a rare opportunity to discuss learning, course design, and teaching in general. Examples are:

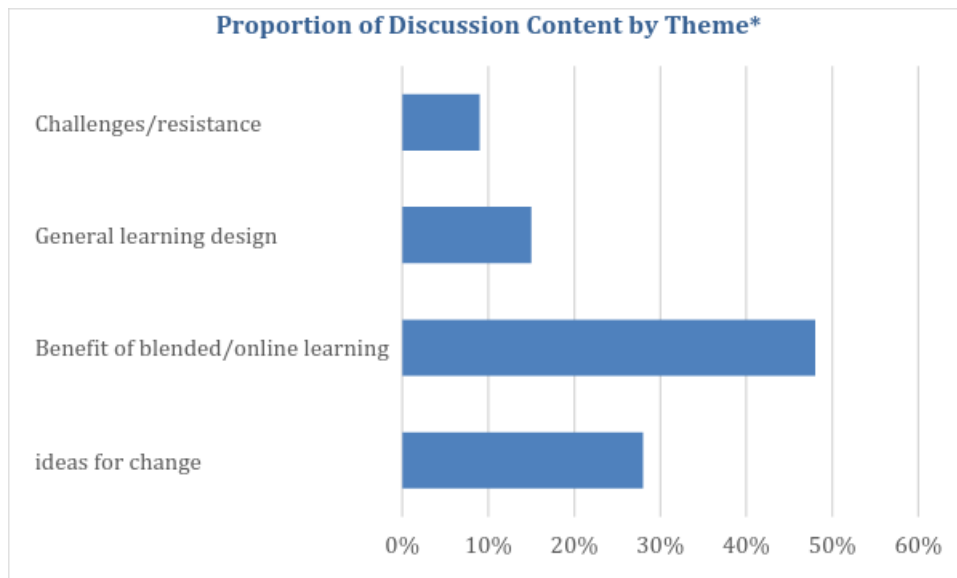
- "... everything you do in the classroom (or in the online classroom) has an element of design and facilitation in it."
- "I think there should be more focus on the social cognition and learning, where students learn in a social environment, where they both learn and exchange from each other to a higher degree."

Benefits of blended/online learning (48%) identifies messages about the topic of benefits of blended and online learning. This includes reflections about the meaning of different aspects of blended and online learning and, once understood, how it might be used. Examples are:

- “Empowering teaching presence to be more efficient in blended methods, is an ability to communicate, give feed-back between lessons, update assignment.”
- “First I must say that I find this discussion forum much more rewarding for my learning than I thought! It clearly gives me some new perspectives on the reading material.”

Ideas for change (28%) includes all messages referring to specific changes faculty were considering in reference to their teaching practice or their courses. Examples are:

- “... use software that is not too much of an obstacle is a first step of course, and to invite any novices to learn tips and tricks from experienced students.”
- “...make sure that the online Col is somewhat wider as compared to the group in classroom ... by making sure that experts from other universities/industry (are included).”



*Please note that this is preliminary data and will be completed with an inter-rater reliability score at the time of the

Figure 1. Proportion of Discussion Content by Theme

DISCUSSION

Our purpose was to identify faculty responses to the idea of using a blended learning design as a key experiential learning strategy while they were engaged in such an environment. Discussion forum messages clarify that participants did engage in the learning experience and, according to some participants, found the unique learning experience itself valuable, as

well as the content.

The community of inquiry that emerged during the course provided a rich environment for faculty discussion. It is possible that this experience explains the large proportion of postings that focused on the benefits of online and blended learning. Faculty both experienced and studied the components of online and blended learning, allowing for thoughtful review and critique of such an environment. The opportunity to explore new ideas about teaching and learning and integrate them, first conceptually through discussion and then in practice through the application exercise, followed the conceptual requirements for a meaningful learning experience as described in the online Community of Inquiry theoretical framework.

Ensuring educationally worthwhile outcomes in engineering education using CDIO requires pedagogical methods that are instructional themselves. While there is no clear narrative yet on how to ensure improved pedagogy in engineering education, the use of blended and online learning has sparked much talk about pedagogy. According to Yigit, Koyun, Yuksel, & Cankaya (2014), “thinking abilities of students who enrolled in the Algorithm and Programming course in blended and traditional education are close” (p. 1). However, learning that includes the pedagogy of web-based engagement allows students to develop more skills related learner independence; skills that transfer for the support of lifelong learning.

Beyond benefits to students, blended learning is “successful in providing an efficient and effective learning experience to both students and faculty” (Shambhavi & Babu, 2015, p. 313). In addition, online and blended learning could be a remedy for some of the challenges in engineering education, where there is a call to “adopt strategies and tools for using a multiple perspectives approach to better understand complex engineering education problems” (Adams, Evangelou, English, de Figueiredo, Mousoulides, Pawley, & Wilson, 2011, p. 48). Engaging engineering faculty in review and discussion about new pedagogies like online and blended learning, pedagogies such as the Community of Inquiry theoretical framework, can provide great benefit to engineering education overall.

CONCLUSIONS

Online and blended learning represents a new wave of teaching and learning which can support teaching quality in general and the implementation of the CDIO standards. (Lucke, Brodie, L., Brodie, I., & Rouvrais, 2016). Improving quality of instruction is a common topic in discussions about higher education reform. Online and blended learning makes good use of available technologies and prepares students for more learner independence, lifelong learning, and competence in the digital world (Duderstat, 2009; Keller, 2008). Integrating information and communication technologies, online learning creates both independence and interaction enabling the creation of learning communities. Online and blended learning has been utilized extensively to enhance classroom learning as well as to increase access to educational experiences at a distance.

To recap, analysis was completed and reported previously on only one section of the course (Cleveland-Innes, Stenbom, & Hrastinski, 2015). Reported here are preliminary findings from analysis of the combined forum discussion data set, Week 2. The entire data set is very large, capturing 5 weeks of forum discussions from 52 participants. Future research will identify how perspectives about blended and online learning change over the span of the course experience.

Two key findings stand out at this early point in our analysis. First, the opportunity to discuss learning design and teaching is a unique and welcome opportunity for faculty and, with the addition of text-based discussion forums between classroom sessions, deeper analysis and more reflection is available. Secondly, faculty are aware that most students have a level of technological literacy more advanced than their own. One participant noted that, one day, faculty accepting teaching positions at KTH will have studied in online and blended environments. Once that occurs, training courses such as this will no longer be required.

We cannot assess the impact of the course on actual teaching practice or course design with the current data set. Future research activity will include interviews with all participants to request information about the longer term effects of this course.

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